AIR QUALITY
in
British Columbia
1983-1987

October 1989

Province of
British Columbia

Ministry of
Environment

90-07344/

Canadian Cataloguing in Publication Data

Main entry under title:
Air quality in British Columbia, 1983-1987

Updates: Air quality trends in British Columbia, 1976-1982.
ISBN 0-7718-8904-6

1. Air quality - British Columbia. I. British Columbia. Ministry of Environment. II. Title: Air quality trends in British Columbia, 1976-1982.

TD883.7.C32B72 1989 363.73'922'09711 C90-092015-7

PREFACE

This report is a follow up to the Air Quality Trends in British Columbia 1976-1982 (Leung and Manna, 1986). The purpose of this document is to provide the public with updated information on air quality in the province of British Columbia.

Rural air quality over much of British Columbia is, in general very good, however emissions as a result of industrial development and transportation do have an impact on certain urban areas of the province. In other areas slash burning and smoke management may be of concern, and the Ministry of Environment, in cooperation with the Ministry of Forests, is working to develop a policy regarding this difficult problem. The Ministry of Environment maintains a network of air quality monitoring sites, particularly in areas with significant emissions to the atmosphere, to regulate those emissions and enforce regulations and to ensure that environmental standards are maintained.

ACKNOWLEDGEMENTS

The assistance and data provided by the Greater Vancouver Regional (GVRD) District are greatfully acknowledged. The GVRD maintains a network of continuous air sampling stations and stores their data as part of the provincial database.

INTRODUCTION

Ambient air quality information is collected by several agencies in the province of British Columbia. The major data sources are the Waste Management Branch of the Ministry of Environment (MoE) and the Greater Vancouver Regional District (GVRD). In addition, data are collected at several industry operated stations, at the request of MoE, and are maintained in the Provincial database. The data collected represent industrial locations, and in the case of many of the GVRD stations, typical urban conditions. Very few stations in the province measure background levels, consequently, the data tend to highlight areas with potential air quality problems.

This report examines ambient air quality from 1983 to 1987 and provides an update of the previous report by Leung and Manna (1986), which described, in more detail, trends for the period 1976 to 1982. The parameters examined in this report include; nitrogen dioxide (NO_2), carbon monoxide (CO), total reduced sulphur (TRS) expressed as hydrogen sulphide (H_2S), sulphur dioxide (SO_2), ozone (O_3), total suspended particulates (TSP), and dustfall.

Table 1 - Pollution Control Objectives for British Columbia

Parameter	Averaging Period	Units	Level A	Level B	Level C
Nitrogen Dioxide	1-hour	µg/m³	400[b]	1000[c]	-
	24-hour		200[b]	300[c]	-
	1-year		60[a]	100[b]	-
Carbon Monoxide	1-hour	mg/m³	14.3	28.0	35.0
	8-hour		55.0	11.0	14.3
Hydrogn (TRS) Sulphide	1-hour	µg/m³	7	28	-
	24-hour		3	6	-
Sulphur Dioxide	1-hour	µg/m³	450[a]	900[b]	-
	24-hour		160[a]	260[b]	800[c]
	1-year		25	75	-
Ozone	1-hour	µg/mg³	100	160[b]	300[c]
	1-year		-	30[b]	-
Total Suspended Particulates	24-hour	µg/m³	150	200	400[c]
	1-year		60[a]	70	-
Total Dustfall	30-day	mg/dm²dy	1.75	2.90	-

Notes: a) Government of Canada "Maximum Desirable Level"
b) Government of Canada "Maximum Acceptable Level"
c) Government of Canada "Maximum Tolerable Level"

The British Columbia Ministry of Environment has published Pollution Control Objectives (PCO) for several industries including, forest products, chemical and petroleum, mining and smelting, food processing, agriculture, and municipal type waste discharges. The Pollution Control Objectives shown in Table 1 are derived from these reports. The objectives have been grouped into three categories, Levels A, B and C. Level A (maximum desirable) objectives are intended to provide long term protection while Level B (maximum acceptable) objectives are intended to provide adequate protection against adverse effects on human health, vegetation and animals. The Level C (maximum tolerable) objectives denote concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general population. The British Columbia air quality objectives are similar to the national air quality objectives defined by the Government of Canada and where appropriate objectives are not set by the PCO, federal objectives under the Canadian Environmental Protection Act (CEPA) are applied. (The GVRD has applied federal objectives, and in many cases these differ from those listed in Table 1.)

The ambient air monitoring stations are generally located near those industry types where specific pollutants are anticipated. For example, most H_2S monitors are located in the vicinity of pulp mills while dustfall sites are located throughout the province with a concentration in the vicinity of interior sawmills and coal mines in the Kootenay region. The number and location of air monitoring stations is not constant and varies throughout the province from year to year. A summary of the parameters measured for the period 1983 to 1987 is shown in Table 2.

Table 2 - Operating Ambient Air Stations

	YEAR				
PARAMETER	'83	'84	'85	'86	'87
Nitrogen Dioxide	13	12	14	15	20
Carbon Dioxide	13	13	14	13	13
Hydrogen Sulphide	12	14	16	19	21
Sulphur Dioxide	16	22	23	22	22
Ozone	15	21	21	24	23
Total Suspended Particulate (TSP)	43	45	81	65	64
Dustfall	74	89	126	118	115

The geographical distribution of the stations operating at the end of 1988 and providing realtime information to the provincial database is given in figures 1a and 1b. The majority of the continuous air monitoring stations are located in the densely populated Lower Mainland. There have been several changes to the data collection network since the previous air quality trends report, with numerous additions to the network. Nitrogen dioxide

collection sites have increased from 13 in 1982 to 20 in 1987. The CO network has remained virtually unchanged over the same period while the number of H_2S measurements has tripled, from the 7 stations operating in 1982, to 21 in 1987. Sulphur dioxide and O_3 measurements have increased, in the period 1983 to 1987, from 17 to 22 and from 13 to 23 respectively.

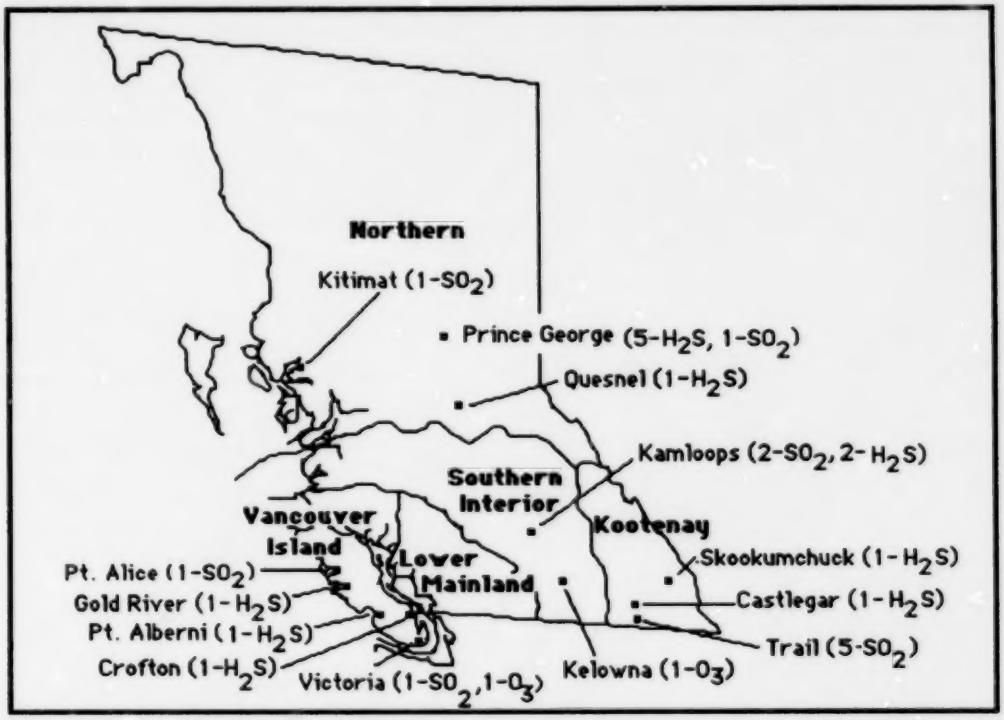

Figure 1a Ambient Air Continuous Analyzer Sites by Region (89/01/01)

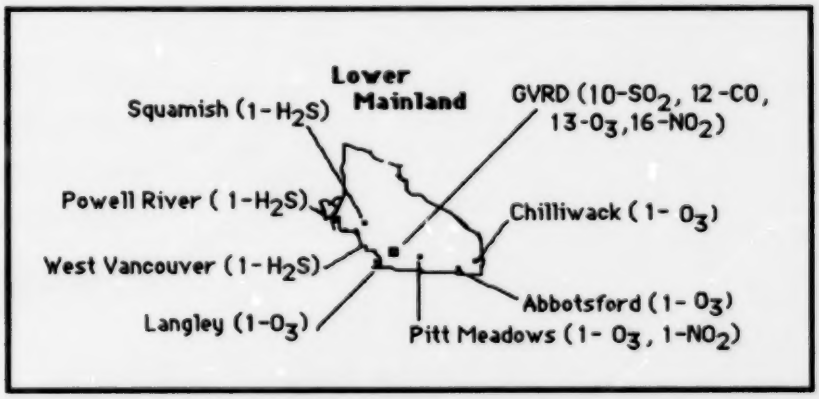

Figure 1b Lower Mainland Ambient Air Continuous Analyzer Sites (89/01/01)

The data presented in this report include the mean annual concentration of the 7 parameters showing the year to year variation. This information is averaged from the mean annual levels of individual pollutants measured at stations across the province. With the exception of TSP, annual concentration values are presented as arithmetic means. TSP data are not normally distributed and a geometric mean is calculated instead. In addition, exceedance data are reported as a percentage of the total number of observations. Percentages are used, rather than absolute number of occurrence, to minimize the problems caused by the number of stations in operation varying from year to year.

GASEOUS ATMOSPHERIC POLLUTANTS

CARBON MONOXIDE

Carbon monoxide (CO) is a tasteless, colourless, non-irritating and odourless gas produced as a result of incomplete combustion of fuels containing carbon. It is a detriment to human health since it has an affinity for haemoglobin approximately 250 times greater than oxygen. A small percentage of CO in the inspired air will be quickly taken up by the body at the expense of oxygen and will result in oxygen starvation of body tissues. The air quality objectives are consequently based on the effects of this gas on human health.

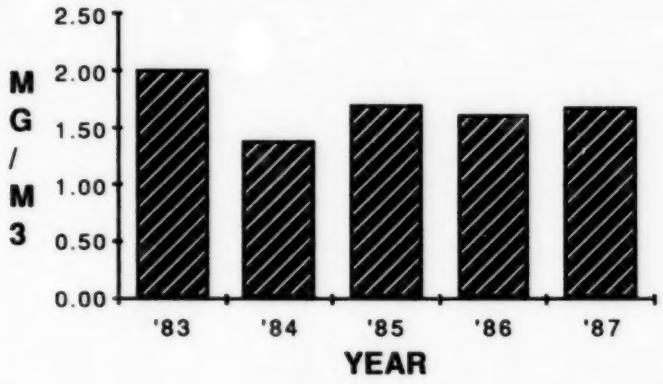

Figure 2 **Average Annual CO Concentration**

Carbon monoxide is a commonly occurring air pollutant and increased concentrations occur in populated areas where there is a high density of motor vehicles. Typically 90% of the man-made sources of CO come from cars, trucks and buses and the levels of CO tend to peak during high traffic periods, especially during the fall and winter, when light winds and stable meteorological conditions are common. The major source of ambient CO is derived from the high concentration of motor vehicles in the Greater Vancouver area. The concentrations of CO have remained relatively constant during the last five years and the annual averages are presented in figure 2. Although consistent from year to year, the values are elevated above those reported in the previous trends report ranging from a low of 1.4 to a high of 2.0 mg/m^3 with an average value of 1.7 mg/m^3.

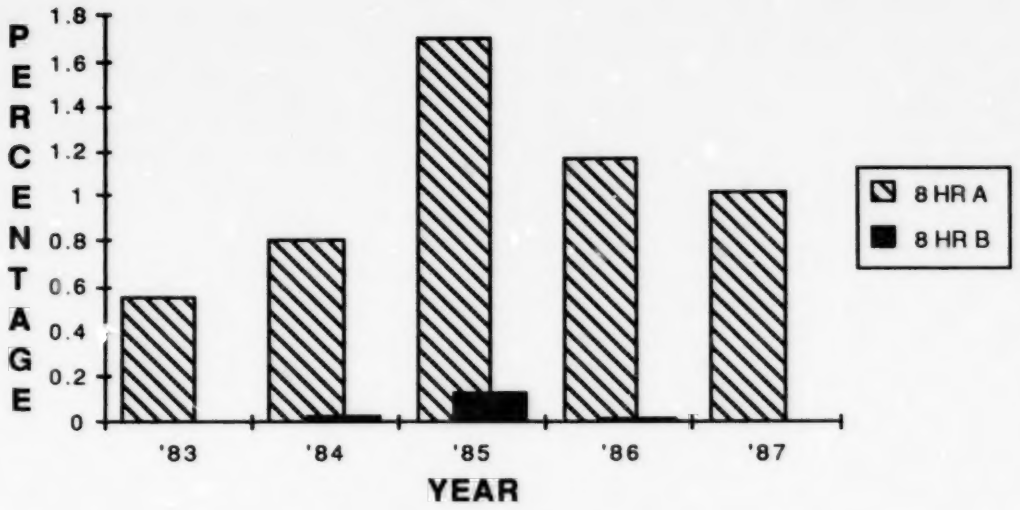

Figure 3 **Percentage 8hr Exceedances CO**

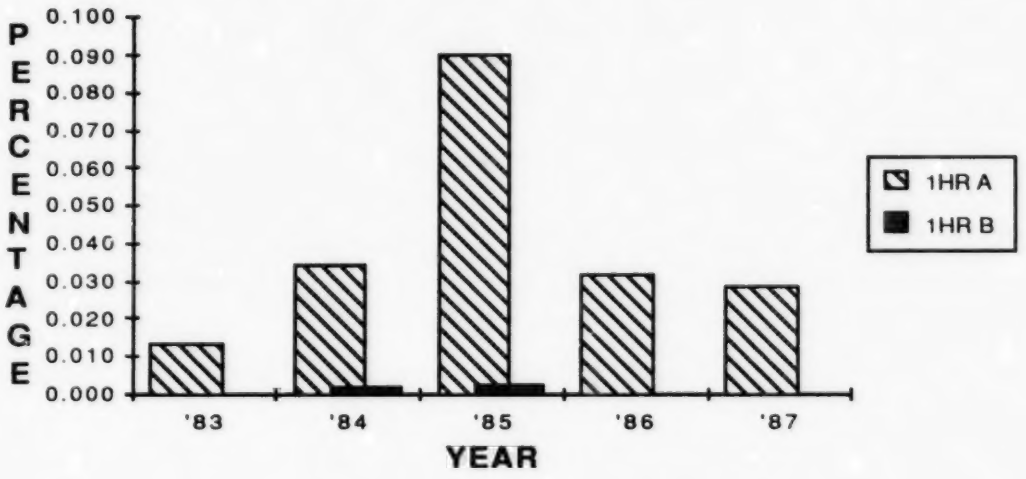

Figure 4 **Percentage 1hr Exceedances CO**

The level A and B exceedances of the 8-hr average CO are plotted in figure 3, expressed as a percentage of the total number of data points collected for each year. These data indicate that in all years less than 1.8% of the 8-hr average CO measurements exceeded the level A criteria of 55.0 mg/m3. There were no level B exceedances in 1983 or 1987. The exceedances increased to a maximum in 1985 and have decreased steadily. The 1hr exceedances, figure 4, show results similar to those reported earlier, with level A objectives exceeded less than 0.1% and level B less than 0.01% in two of the five years.

HYDROGEN SULPHIDE (TRS)

Total reduced sulphur compounds (TRS), expressed in the form of hydrogen sulphide (H_2S), a by-product of many industrial processes including Kraft pulp mills, oil refineries and natural gas processing plants, is colourless with an odour of rotten eggs. This gas can be very dangerous at higher concentrations, however, under lower conditions normally found in the ambient air, the major concern to the public is due to its malodorous nuisance effect.

The average H_2S concentration, figure 5, was 2.7 $\mu g/m^3$ with the values falling into the same range of 2 to 4 $\mu g/m^3$ as was observed in the 1976 to 1982 report prepared by Leung and Manna. The 1984, 1986 and 1987 values were below the mean value and the 1987 value was approximately 30% below that observed in 1983 .

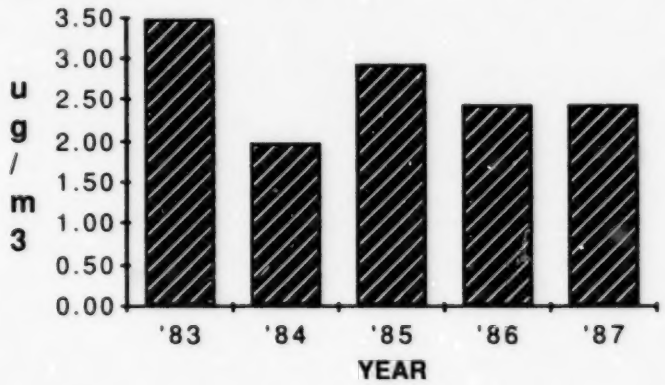

Figure 5 **Average Annual H_2S Concentration**

The percentage of the 24-hr values that exceeded the level A and B objectives are presented in figure 6. Level A exceedances ranged from 17 to 26%, a slight increase over the previous reporting period. The level B objectives were exceeded on average approximately 14% of the time, ranging from a low of 11% in 1985 to a high of 18% in 1983. These values are very similar to the values reported for 1976-82.

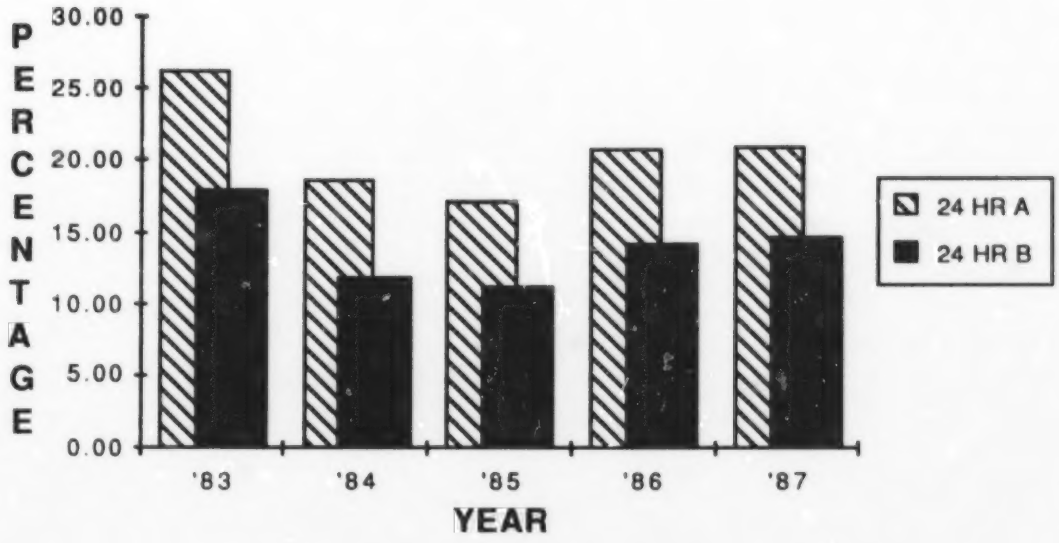

Figure 6 **Percentage 24hr Exceedances for H_2S**

The 1hr level A exceedances for the period (figure 7) varied from 6.8 to 10.5%, less than the 10 to 20% reported previously for 1976 to 1982. The 1hr level B exceedances were also reduced ranging from 2 to 4% compared with 2 to 6% for the preceding period.

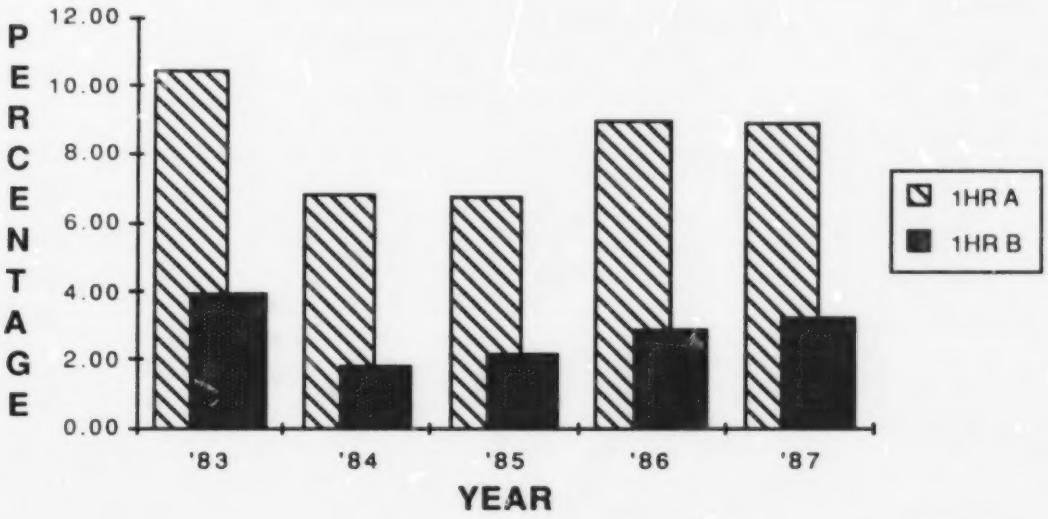

Figure 7 **Percentage 1hr Exceedances H_2S**

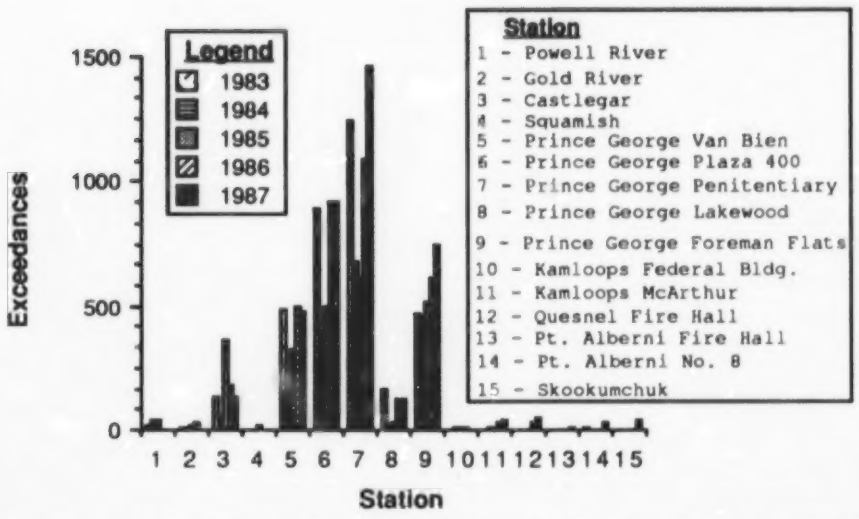

Figure 8 **Annual Exceedances of Level B 1hr H_2S at stations with 5 or more exceedances per year (corrected for missing data).**

In general the H_2S average values and exceedances were reduced in the period 1983-87 compared with the period 1976-82. Those sites with more pronounced exceedances are presented in figure 8. Six stations have had more than 100 level B exceedances in a year, five of the stations are located in the Prince George area, the sixth in Castlegar. The seriousness of the H_2S problem in the Prince George area prompted a detailed study by the Waste Management Branch in consultation with local industry. The study identified the sources of the problem and a control strategy was established. In December 1988 the Ministry of Environment announced the implementation of a control program the total cost of which is to be borne by industry and is estimated at $25 to 50 million.

The high levels of H_2S in the Castlegar area are currently under investigation by the Ministry. The problem of H_2S recovery is being evaluated and a control strategy is being prepared. In the interim the mill has been granted a 'variance' under the Waste Management Act to ensure air quality levels do not exceed 70 $\mu g/m^3$.

SULPHUR DIOXIDE

Sulphur dioxide is one of the most widely measured of the continuous air samples taken within the province. The gas is colourless with a pungent odour and can be detected by both taste and smell at levels as low as 800 $\mu g/m^3$. Sulphur dioxide is highly soluble in water and it is one of the major contributors to the problem of acidic precipitation.

The sources of SO_2 within the province include pulp mills,

smelters, natural gas processing plants and the combustion of fuels with high sulphur content. Air quality objectives for this pollutant are primarily established on the basis of its impact on human health, vegetation and materials. In humans, exposure to SO_2 and its atmospheric byproducts can cause respiratory and cardiac problems.

Average annual concentration of SO_2 over the period 1983 to 1987 is given in figure 9. The average concentration over the period has increased to approximately 32 $\mu g/m^3$ from the previous value of 25 $\mu g/m^3$ for 1976 to 1982, an increase of 20%. Annual average values range from 26.4 to 38.9 $\mu g/m^3$, peaking in 1986 and decreasing to 31.9 $\mu g/m^3$ in 1987. In all cases the average annual values exceed the 25 $\mu g/m^3$ level A objectives for SO_2, in the previous reporting period this threshold was exceeded in 4 of the 5 years studied.

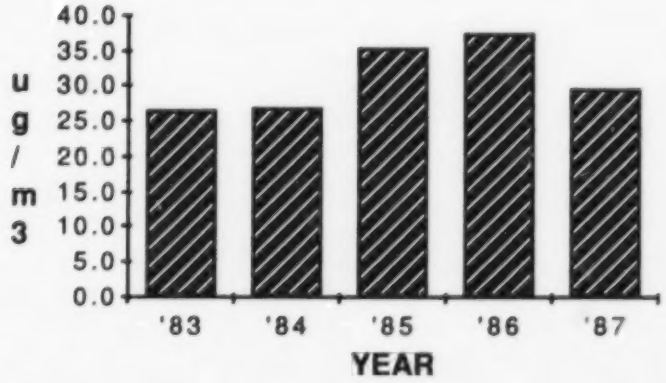

Figure 9 **Average Annual SO_2 Concentration**

The exceedances of the 1hr level A and B objectives are given in figure 10. The level A objective exceedances ranged from 0.9 to 1.7% with an average of 1.4%. In all years the number of level A exceedances are higher than those reported in the 1976-82 report. The level B objective exceedances ranged from 0.6 to 0.2% and are similar to those reported earlier.

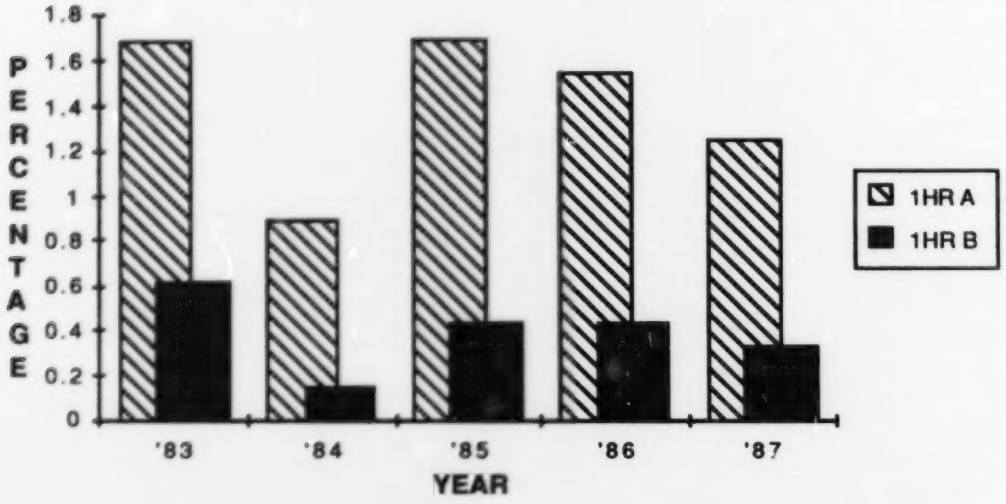

Figure 10 **Percentage 1hr Exceedances SO_2**

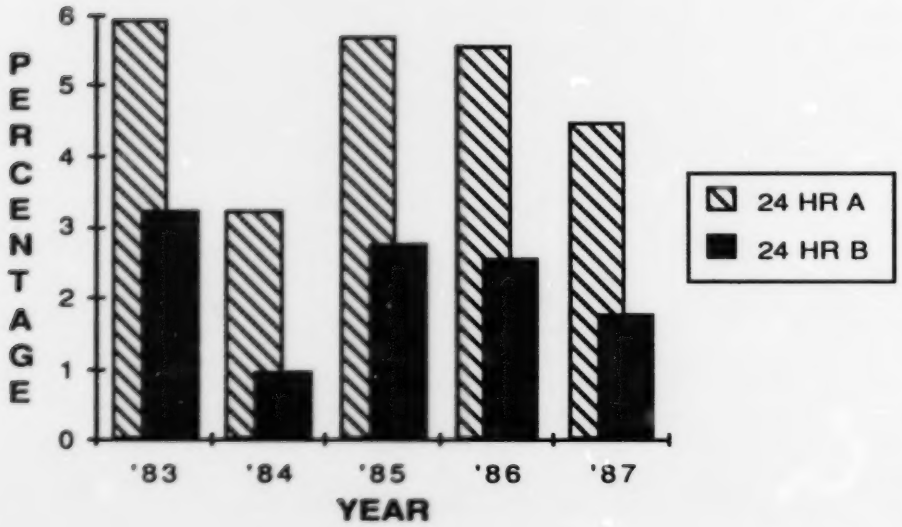

Figure 11 **Percentage 24hr Exceedances SO_2**

The percentage 24hr exceedances for SO_2 are given in figure 11. Level A exceedances ranged from 3.2 to 5.9% and averaged 5.0%. Level B values ranged from 1.0 to 3.2% with an average of 2.3%. In both cases the number of exceedances is higher than that reported in the 1976 to 82 report.

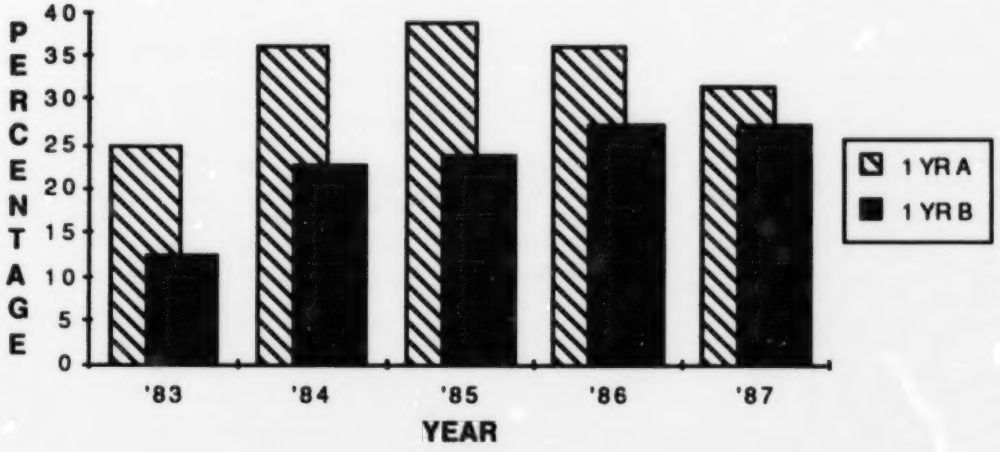

Figure 12 **Percentage Annual Exceedances SO_2**

On an annual basis, with the exception of 1976, the exceedances are higher in all years than those reported earlier. Level A exceedances range from 25 to 39% and level B from 13 to 30%. The annual exceedances of the level A and B objectives are presented in figure 12. The level A exceedances peaked in 1985 and have shown a slight decrease in the last 2 years. The level B exceedances, however, have been increasing steadily since 1980.

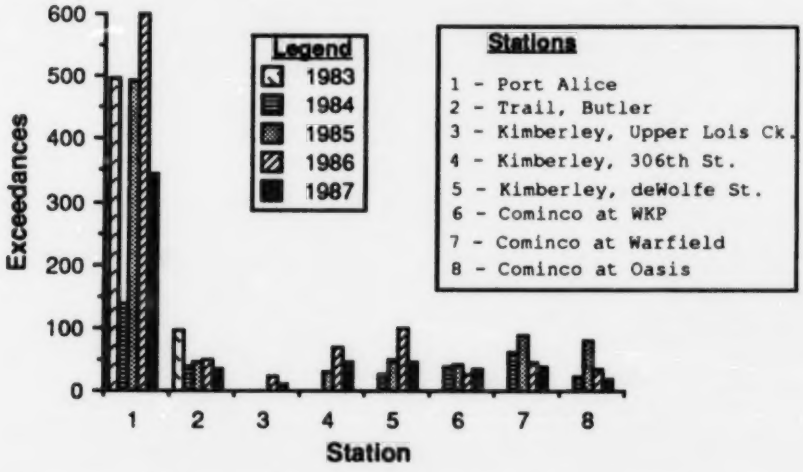

Figure 13 **Annual exceedances of Level B 1 hr SO_2 at stations with 5 or more exceedances per year (corrected for missing data)**

The steady increase in the SO_2 level B exceedances has warranted further study and the exceedance data for eight individual stations in the vicinity of high sources of SO_2 is presented in figure 13. Eight stations have recorded 5 or more 1 hr level B exceedances in a year over the period 1983 to 1987, however only one station, Port Alice, has consistently recorded more than 100 exceedances per year in each of the 5 years of this study. In four of the five years the values have ranged from 145 to 599 Level B exceedances. The Ministry of Environment is currently studying both the long and short-term impacts of this mill on the air quality of Northern Vancouver Island. The study is ongoing and potential control strategies are being investigated.

OZONE

Ozone is a minor constituent of Earth's atmosphere found in varying quantities from the surface to a height of 60 km. High elevation O_3 is important in protecting the planet's inhabitants from the harmful effects of ultraviolet radiation. Scientists are concerned at the decrease in high elevation O_3 caused by such products as chlorofluorocarbons (CFC's). In some urban areas, under the appropriate meteorological conditions, O_3 in the lower atmosphere may increase for brief periods. Unfortunately, the increased level of O_3 does not migrate to the upper atmosphere.

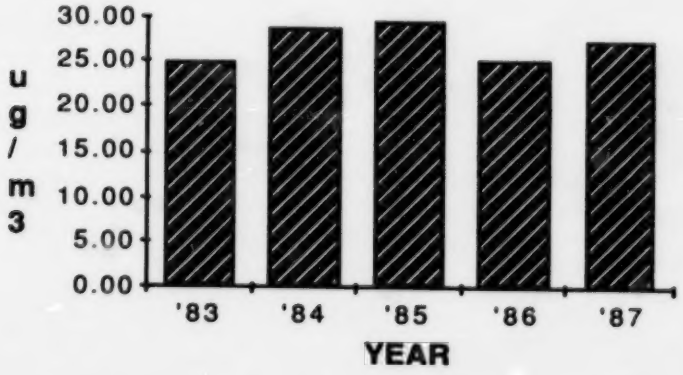

Figure 14 **Average Annual O_3 Concentration**

Ozone is a reactive form of oxygen created, in the presence of sunlight, through chemical reactions with nitrogen oxides and hydrocarbons. It can irritate eyes and the respiratory tract and reduce crop yields. The main source of low elevation O_3 is a result of chemical reactions with other atmospheric constituents and motor vehicle emissions. Ozone levels generally peak in the summer months, a result of increased motor vehicle activity, increased sunlight and the appropriate meteorological conditions. The average annual O_3 values are given in figure 14. The mean annual

concentration for 1983 to 1987 was 27.3 µg/m³ and the average values for all years were below the Federal Maximum Acceptable objective of 30 µg/m₃. These results are similar to those reported for the 1976 to 1982 period.

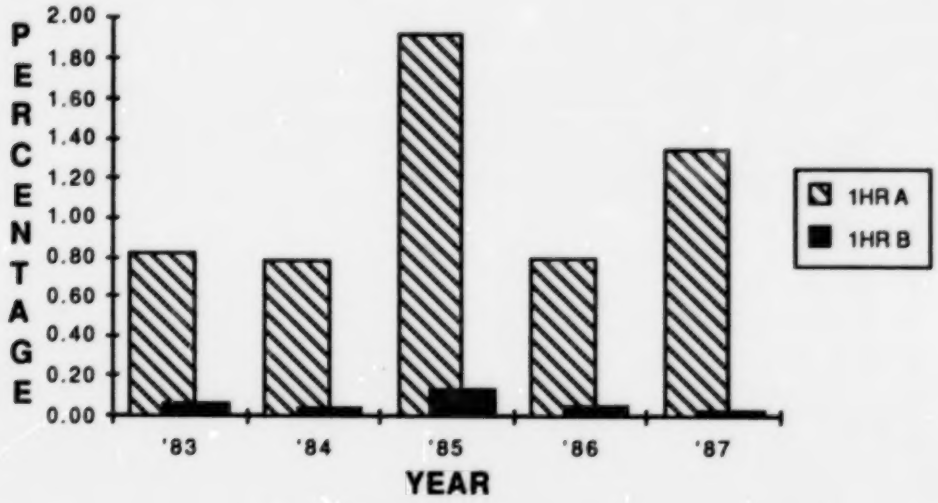

Figure 15 **Percentage 1hr Exceedances O_3**

The percentages of 1 hour exceedances for level A and B are given in figure 15. The average level A annual exceedance was 1.1%, down from the previously reported 2% for 1976 to 1982. Level B exceedances were reduced dramatically to less than 0.15% (less than 1% previously), with an average value of less than 0.07%. These reductions may be due, in part, to significant improvements in new motor vehicle controls and increased fuel economy and more stringent industrial controls. As the proportion of newer vehicles increases, emissions resulting in ozone should be reduced, however, there is concern this will be at least partially offset by increasing numbers of vehicles as the population grows.

The reduction in level B exceedances was not uniform, with certain areas of the Lower Mainland, where the majority of the analyzers are located, reporting elevated O_3 levels, as shown in figure 16. The two main areas of concern are Burrard Inlet and the Fraser Valley from Surrey to Chilliwack. The GVRD and Ministry of Environment maintain a detailed network of ambient air monitoring stations in these areas.

An inventory of source emissions for the GVRD and Fraser Valley has recently been completed and the GVRD has prepared an Air Management Plan for the area. In addition, both the Ministry of Environment and the GVRD are evaluating current state of the art photochemical dispersion models in an attempt to quantify and identify control actions for the O_3 problem in the Lower Mainland.

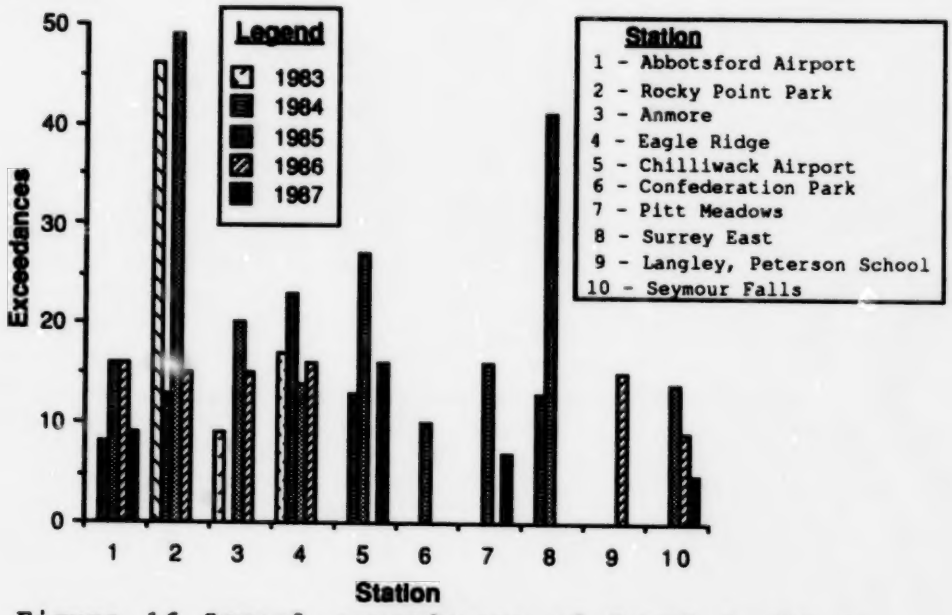

Figure 16 **Annual exceedances of Level B 1hr O_3 at stations with 5 or more exceedances per year (corrected for missing data)**

NITROGEN DIOXIDE

Nitrogen dioxide (NO_2) is produced during the high temperature combustion of fossil fuels. It is a reddish-brown gas with a pungent odour and it is monitored at sites in the lower mainland. Motor vehicles are the major source of NO_2 in urban areas of the province. This gas plays an important role in atmospheric photochemical reactions and O_3 formation and, along with SO_2, is a major contributor to the problem of acidic precipitation. In addition, NO_2 may cause and/or accentuate respiratory problems.

The annual average NO_2 concentration for the 1983 to 87 period are given in figure 17. The mean for the five year period was 38.3 $\mu g/m^3$, well below the one year level A objective of 60 $\mu g/m^3$ and similar to those results reported for the period 1976 to 1982.

Exceedances of the level A objectives were rare, with only 0.01% (1984) observed for the 1hr and 0.03% (1984, 85) for the 24hr exceedances. For both of these periods no Level B exceedances were observed in any of the five years studied. Exceedances for the 1 year period were again limited to level A, no level B exceedances were observed. These results are similar or somewhat improved from those reported for the 1976 to 82 period.

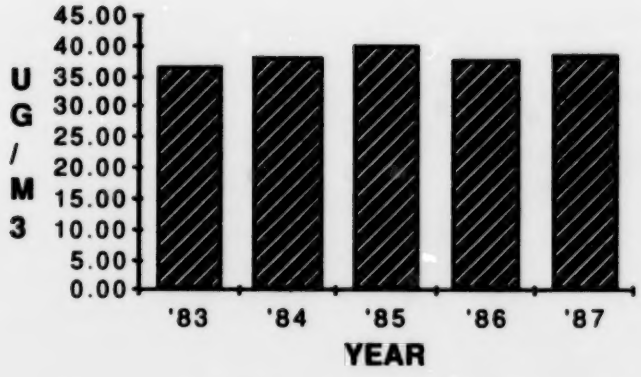

Figure 17 **Average Annual NO_2 Concentration**

PARTICULATE ATMOSPHERIC POLLUTANTS

TOTAL SUSPENDED PARTICULATES

Total suspended particulates (TSP) include airborne particles in the 0.1 to 100 µm size range. The sources of these materials are diverse, ranging from residential wood heaters, the burning of fossil fuel, sawmill beehive burners, mining, slash burning, to pollen. The problems with TSP are similarly wide in scope and may include impaired visibility to impact on health. The health implication of particulate levels is related to the size of the particles, with more serious respiratory difficulties encountered with particles smaller than 10 µm. In addition, different particle types have varying degrees of toxicity and this will contribute to their impact on human health.

Unlike the previously presented data in this report, which used arithmetic means, the geometric mean is used to present TSP results. The annual geometric mean TSP concentrations are presented in figure 18.

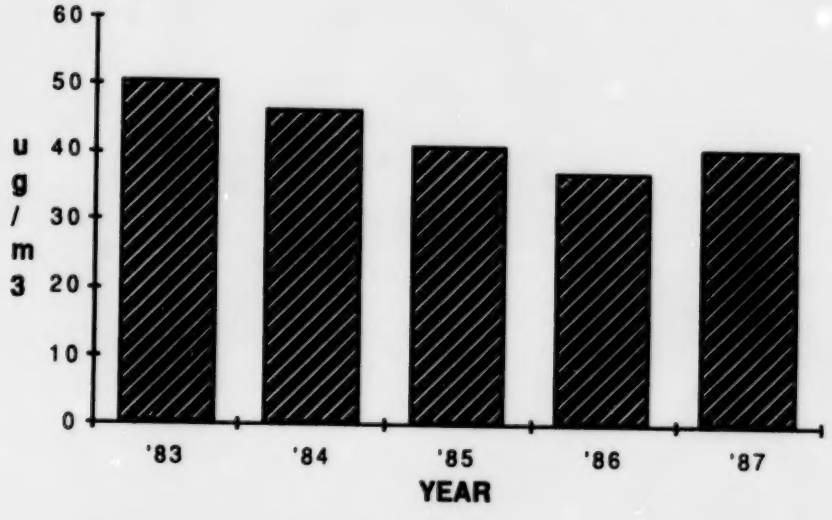

Figure 18 **Annual Geometric Mean (TSP)**

In the years 1983 to 1985 the annual geometric mean did not exceed the level A objective of 60 µg/m^3. The five year average (43.1 µg/m^3) also did not exceed this criteria. The mean annual value reported in the previous report was also below the level A objective and the annual values exceeded that objective in only one year. Individual stations, such as Merritt and Quesnel, have reported more than 5 exceedances of the 24 hour level B objective per year. The vast majority of the TSP sensors reported few excursions above the level A objective. However, the Ministry of

Environment is aware that inhaled particulates less than 10 µm (PM_{10}) may pose a serious health problem. Since this size of particulate is a major component of smoke, the measurement of TSP may be replaced with the more appropriate PM_{10}.

DUSTFALL

Dustfall is the most commonly measured atmospheric pollutant collected in British Columbia. It consists of solid particles that settle out of the atmosphere near the source of the emission. Most dustfall collectors are located near major sources of emission such as wood-waste burners and coal mines. Dust can impede visibility, soil surfaces and in general be a nuisance. Annual average dustfall data are presented in figure 19. Average dustfall reached a minimum in 1985 rising to a value in excess of the level A objective in 1987. The average for the five year period (1.62 mg/dm²/dy), and all the annual values, are lower than those reported for the 1976 to 1982 period. This may be due to the reduced numbers of stations in the current dustfall collection network.

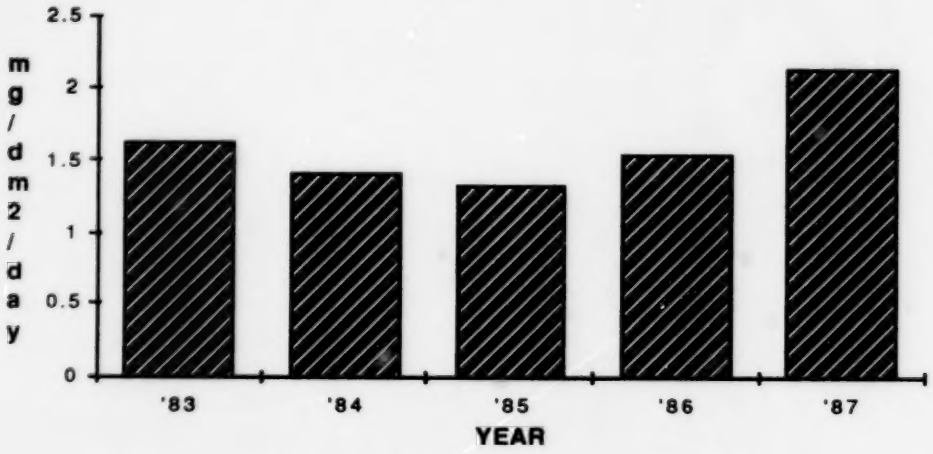

Figure 19 **Annual Dustfall**

Several stations have reported consistent level B exceedances, these include Port Alberni, Canal Flats, Grand Forks, Lavington, Lumby, Malakwa, Merritt, Okanagan Falls, Quesnel, Summerland and Williams Lake. The majority of these sites are being improved through cooperation between the municipality and industry under the direction of the Ministry of Environment. To alleviate this problem, revamping of the wood-waste burners has been undertaken or is planned for Port Alberni, Grand Forks, Lavington, Canal Flats, Okanagan Falls and Williams Lake. In addition, the City of Merritt, in cooperation with the Ministry of Environment and industry, has established a committee to determine a solution to the fugitive dust problem in their municipality. Unsolved dust related problems remain in Lumby, Malakwa, Quesnel and Summerland.

SUMMARY

In general, air quality in British Columbia has remained similar to that reported in Leung and Manna (1986). Some pollutants, such as NO_2 have remained at levels consistent with those reported earlier. Both the annual averages and exceedances were unchanged. The 24hr exceedance and annual average for H_2S along with the annual average for O_3 were also essentially unchanged.

Decreases were recorded in the 1hr exceedances for H_2S and O_3, and in the annual average values of TSP and dustfall. The large decrease in dustfall was difficult to interpret due to the large change in the number of data collection sites between the two periods.

A slight increase was noted in the annual average CO during the period 1983 to 1987. The most serious increase over the last 5 years has undoubtedly occurred with SO_2. Annual average SO_2 concentration has increased by approximately 20%, in addition, exceedances have also been increasing. These increased levels are primarily due to deteriorating levels of air quality at the Port Alice air monitoring site, due to atmospheric emissions from the sulphite pulp mill located in the vicinity. One hour level A exceedances were higher in all years than those reported for 1976 to 1982. The mean percentage of both level A and B exceedances for 24 hours increased in the 1983 to 1987 period. Level A increased from 3.2 to 5.0% and level B from 1.3 to 2.3%. The current results show a steady increase of 450% in level B annual exceedances since 1980 (6 to 27%, over the 8 year period).

Finally, it must be restated that ambient air quality measurements, by their nature, are measured in the vicinity of potential pollution sources and as a result are typical of industrial and/or urban areas. They are not typical of the vast rural and undeveloped portions of our province. The year to year collection of data has enabled the Ministry to evaluate the air pollution trends and initiate regulatory controls and enforcement programmes as necessary.

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